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Distribution of asteroid genera (Echinodermata) off South Shetland Islands and the Antarctic Peninsula

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ABSTRACT

Frequency and distribution of asteroid genera in the South Shetlands zone are analysed, based on data from 24 Agassiz trawls carried out during the Bentart 95 Survey. Asteroids were collected at more than 90 % of the stations, on all types of bottoms, with richness per station ranging from 0-10 genera. The specimens belonged to 27 genera and 12 families, with Astropectinidae, Goniasteridae and, above all, Asteriidae having the highest number of representatives (3 and 7 genera, respectively). *Odontaster* Verrill, 1880 and *Labidiaster* Lütken, 1872, followed by *Psilaster* Sladen, 1885 and *Diplasterias* Perrier, 1888, were found to have the widest distribution and highest occurrence. *Odontaster* was more frequent to a depth of 100 m, and *Labidiaster* between 200 and 300 m. The rarest genera were *Notioceramus* Fisher, 1940 and *Chitonaster* Sladen, 1889, endemic to Antarctic waters.

Stations showing the highest richness (10 genera) were those located near the Antarctic Peninsula and north of Livingston Island. Asteroid poverty was noticeable inside Deception Island, where a mere 3 genera were recorded.

As shown by similarity and grouping analysis based on presence-absence data, stations are mainly grouped in relation to genera richness when double absence is considered. These results show the distintiveness of the stations around Deception Island, probably due to its special geological characteristics.

Key words: Frequency, distribution, richness, genera, Asteroidea, Echinodermata, South Shetlands, Antarctic Peninsula.

RESUMEN

Distribución de los géneros de asteroideos (Echinodermata) de las islas Shetland del Sur y península antártica

Se analizan la frecuencia y distribución de los géneros de Asteroidea en la zona de las islas Shetland del Sur a partir en los datos obtenidos en 24 arrastres con Agassiz efectuados durante la campaña Bentart 95. Las estrellas fueron recogidas en más del 90 % de las estaciones, sobre todo tipo de fondos, con riqueza que osciló entre 0-10 géneros. Los asteroideos encontrados pertenecieron a 27 géneros y 12 familias, siendo Astropectinidae, Goniasteridae y, sobre todo, Asteriidae, las familas con el número más elevado de representantes (3 y 7 géneros, respectivamente). Odontaster *Verrill, 1880 y* Labidiaster *Lütken, 1872, seguidos por* Psilaster *Sladen, 1885 y* Diplasterias *Perrier, 1888 presentaron la más amplia distribución y la frecuencia más elevada.* Odontaster *fue más frecuente hasta 100 m de profundidad y* Labidiaster *entre 200-300 m. Los géneros más raros fueron* Notioceramus *Fisher, 1940 y* Chitonaster *Sladen, 1889, endémicos de aguas antárticas.*

Las estaciones que mostraron una riqueza más alta (10 géneros) fueron las localizadas cerca de la península antártica y el norte de la isla Livingston. La pobreza de asteroideos fue notable en el interior de la isla Decepción, donde se encontraron sólo tres géneros.

Palabras clave: *Frecuencia, distribución, riqueza, géneros, Asteroidea, Echinodermata, islas Shetlands del Sur, península antártica.*

INTRODUCTION

Since the voyage of the *Belgica* (1897-1899), many expeditions have gathered asteriods in the Southern Ocean, specifically, in the South Shetlands and Antarctic Peninsula zones. Since the beginning of the present century, Ludwig (1903), Koehler (1906, 1912, 1923), Grieg (1929), Fisher (1940), Clark (1950) and Bernasconi (1959, 1970) have all described the material collected during expeditions carried out in this area.

Of 114 species and 50 genera of Asteroidea that have been cited in the Antarctic Ocean (Fisher, 1940; Dell, 1972), 32 species grouped in 19 genera and 8 families have been recorded in the area of the Antarctic Peninsula and South Shetlands Islands (Bernasconi, 1970).

Reviews of Asteroidea have been published by Fell and Dawsey (1969), Dell (1972), and Pawson (1994). Characteristics of Antarctic asteroids are their wide circumpolar distribution (Dell, 1972), lack of planktonic larvae, frequent brooding, and widely-varying feeding habits. These range from diets based exclusively on hexactinellid sponges, as is the case of some species of the *Acodontaster* Verrill, 1899 and *Perknaster* Sladen, 1889 genera, and winter or optional necrophagy, to the absolute opportunism of *Odontaster validus* Verrill, 1880, which can even be suspension-feeders (Dearborn, 1977; Arnaud, 1977; Presler, 1986). But in spite of the progress in biological studies, general knowledge and information on the systematic ecology of this group is still incomplete, and basic distribution patterns need to be checked in light of new findings (Pawson, 1994).

During the Spanish Bentart 95 Survey, the benthos was sampled off northern and southern Livingston Island, Deception Island and Bransfield Strait, using different gears (Ramos, unpublished; Saiz-Salinas *et al.*, 1997; San Vicente *et al.*, 1997; Arnaud *et al.*, 1998). The asteroids were collected during 24 Agassiz trawls carried out for epifauna studies (figure 1). Although a portion of these starfishes have already been identified down to the species level, the taxonomic difficulties involved have prevented us from completing this determination. We have preferred, in this first paper, to conduct a general analysis of the frequency, distribution and associations of asteroid genera, relating this data to possible determining factors.

MATERIALS AND METHODS

Field sampling

During the Bentart 95 campaign, epifauna were sampled at 24 stations ranging from north of Livingston (Drake Passage) and the Antarctic Peninsula, at depths of 40-1 019 m (figure 1 and table I).

Sampling was carried out mainly by Agassiz trawl with 2.01 m and 1.12 m horizontal and vertical openings, and 10 mm mesh. Trawlings lasted 5 minutes, at 2.5 knots (Ramos, unpublished).

At each station, a subsampling of 50 litres was randomly collected, following the semi-quantitative method developed during the EPOS Program on board the *Polarstern* (Arnaud *et al.*, 1990). This sampling was sieved through three mesh sizes (10, 5 and 1 mm) and asteroids retained in the 10 mm sieve were counted and weighed in order to estimate their relative abundance in the total macrofauna. Asteroid specimens from the rest of the catch were also collected. All material was preserved in 70 % alcohol.

Laboratory work

Once on land, asteroids were checked and transferred to flasks with a new 70 % alcohol solution. For taxonomic determination based on external morphological characters, we used a Wild 308700

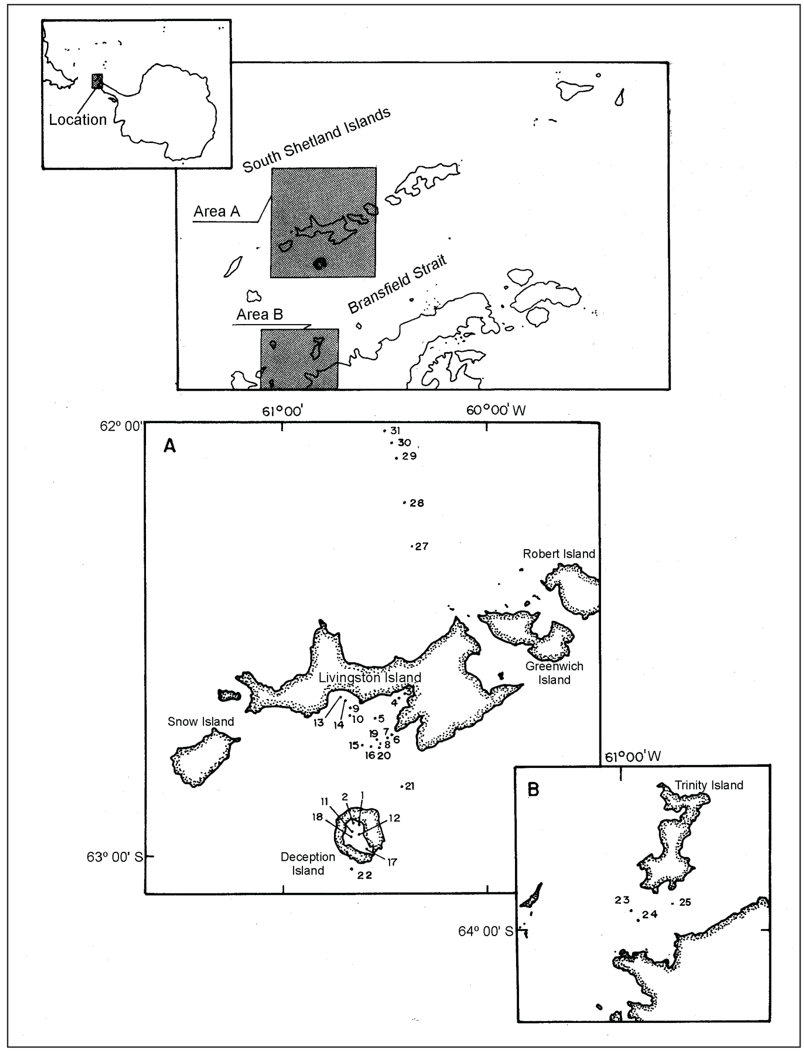

Figure 1. Location of the Bentart 95 Cruise study zone, with the position of Agassiz trawl stations

magnifying glass, with an Olympus Highlight 3001 to illuminate optical fibres, and consulted the works of Clark (1962), Clark (1963) and Bernasconi (1964, 1970).

The Jaccard coefficient (Jaccard, 1908; Real and Vargas, 1996), Baroni-Urbani coefficient (Baroni-Urbani and Buser, 1976) with the UPGMA agglomeration algorithm (Sneath and Sokal, 1973), and correspondence analysis (Ter Braak and Prentice, 1988) were applied for grouping and ordering stations based on qualitative faunistic results.

RESULTS

Faunistic composition and genera occurrence

We examined 760 asteroid specimens from samplings of Agassiz trawls. Their taxonomic classification according to Koehler (1906), Clark (1962, 1989, 1993, 1996), and Bernasconi (1964) is shown in table II. The resulting taxonomic list included 12 families and 27 genera. Families represented by the highest number of genera were Astropectinidae and Goniasteridae, with 3 each, and Asteriidae, with 7.

Asteroids were found throughout the study zone, at 23 stations (91 %), from depths of 40-1 019 m, on all bottom types: soft, mixed and hard.

Genera that presented the widest distribution were *Odontaster* Verrill, 1880, which was found at 11 stations, and *Labidiaster* Lütken, 1872, at 9, followed by *Psilaster* Sladen, 1885 and *Diplasterias* Perrier, 1888 (table III). *Odontaster* was more frequent to a depth of 100 m in all areas, and *Labidiaster*, from 200-300 m. *Bathybiaster* Danielssen & Koren, 1882, *Luidiaster* Studer, 1883 and *Acodontaster*, among other genera, were not found

Table I. Agassiz trawl stations list, with location and characteristics (depth and bottom type)

Station	Date	S Latitude	W Longitude	Depth (m)	Bottom type
1	23-01	62° 55.01'	60° 36.44'	40	Gravel
2	16-01	62° 56.29'	60° 38.71'	148	Mud
3	17-01	62° 37.70'	60° 22.81'	92	Mud
4	17-01	62° 38.45'	60° 24.18'	173	Mud
5	23-01	62° 41.68'	60° 31.81'	256	Mud
6	18-01	62° 43.58'	60° 26.96'	49	Mud
7	18-01	62° 44.12'	60° 27.70'	80	Mud
9	19-01	62° 39.56'	60° 38.62'	182	Gravel and mud
10	21-01	62° 40.53'	60° 38.95'	220	Mud
11	20-01	62° 56.86'	60° 39.34'	167	Mud
12	20-01	62° 57.67'	60° 38.00'	167	Mud
15	22-01	62° 45.79'	60° 35.70'	335	Mud
16	24-01	62° 45.17'	60° 33.10'	429	Mud
17	23-01	62° 59.36'	60° 33.85'	107	Sand
18	24-01	62° 58.10'	60° 40.24'	114	Sand
19	25-01	62° 43.73'	60° 31.46'	235	Mud
22	31-01	63° 03.55'	60° 39.54'	330	Gravel
23	29-01	63° 57.14'	60° 59.73'	141	Gravel
24	30-01	63° 58.52'	60° 52.60'	233	Gravel
27	02-02	62° 20.41'	60° 19.67'	70	Mud and gravel
28	02-02	62° 12.12'	60° 23.18'	126	Mud
29	03-02	62° 05.16'	60° 25.94'	237	Mud
30	03-02	62° 01.41'	60° 26.26'	710	Mud and gravel
31	04-02	62° 01.40'	60° 28.84'	1 019	Mud

south of Livingston, appearing at stations close to the Antartic Peninsula and Drake Passage. Many genera, including *Cryptasterias* Verrill, 1914, *Neosmilaster* Fisher, 1930, *Sclerasterias* Perrier, 1891, *Luidiaster*, *Chitonaster* Sladen, 1889, *Macroptychaster* H. E. S. Clark, 1963, *Cladaster* Verrill, 1899, *Cycetra* Bell, 1881 and *Notioceramus* Fisher, 1940, were only collected at a single station.

Richness, expressed as the number of genera per station (figure 2), ranged from 0 to 10, of the total of 27 found. It exhibited major variations in relation to geographical areas; the highest number of genera, 10, were found at station 28 in Drake Passage. The asteroid poverty inside Deception Island, where only a few specimens of O*dontaster* were recorded, was noteworthy. No asteroids were found at two stations (2 and 11).

Affinity between stations

No geographical boundaries have been detected using Jaccard's similarity index applied to qualitative genera distribution, due to the high hetero-

Table II. Taxonomic list

Order Paxillosida
- Family Astropectinidae Gray, 1840
  - *Macroptychaster* H. E. S. Clark, 1963
  - *Psilaster* Sladen, 1885
  - *Bathybiaster* Danielssen & Koren, 1882

Order Notomyotida
- Family Benthopectinidae Verrill, 1899
  - *Luidiaster* Studer, 1883

Order Valvatida
- Family Odontasteridae Verrill, 1899
  - *Odontaster* Verrill, 1880
  - *Acodontaster* Verrill, 1899
- Family Goniasteridae Forbes, 1841
  - *Chitonaster* Sladen, 1889
  - *Notioceramus* Fisher, 1940
  - *Cladaster* Verrill, 1899
- Family Ganeriidae Perrier, 1894
  - *Cycethra* Bell, 1881
  - *Perknaster* Sladen, 1889
- Family Asterinidae Gray, 1840
  - *Patiria* Gray, 1840
  - *Kampylaster* Koehler, 1920
- Family Poraniidae Perrier, 1893
  - *Porania* Gray, 1840

Order Velatida
- Family Solasteridae Vignier, 1878
  - *Lophaster* Verrill, 1878
  - *Cuenotaster* Thiery, 1920
- Family Korethrasteridae Danielssen & Koren, 1884
  - *Remaster* Perrier, 1894

Order Spinusolida
- Family Echinasteridae Verrill, 1870
  - *Rhopiella* Fischer,1940
  - *Henricia* Gray, 1840

Order Forcipulatida
- Family Labidiasteridae Verrill, 1914
  - *Labidiaster* Lütken, 1872
- Family Asteriidae Gray, 1840
  - Subfamily Cocinasterinae Fisher, 1923
    - *Notasterias* Koehler, 1911
    - *Lethasterias* Fisher, 1923
    - *Sclerasterias* Perrier, 1891
  - Subfamily Asteriinae Verrill, 1914
    - *Lysasterias* Fisher, 1908
    - *Cryptasterias* Verrill, 1914
    - *Diplasterias* Perrier, 1888
    - *Neosmilaster* Fisher, 1930

Table III. Presence-absence data of Asteroid genera in Agassiz trawls. (D): Deception Island; (SL): South Livingston; (NL): North Livingston; (B): Bransfield Strait

Genus	D1	D2	SL5	SL6	SL7	SL9	SL10	D11	D12	SL15	SL16	D17	D18	SL19	B22	B23	B24	NL27	NL28	NL29	NL30	NL31	**Total**
Acodontaster																1	1						**2**
Bathybiaster										1							1			1	1		**4**
Chitonaster										1													**1**
Cladaster																	1						**1**
Cryptasterias						1																	**1**
Cuenotaster											1					1							**2**
Cycethra																						1	**1**
Diplasterias			1	1						1						1	1	1	1		1		**8**
Henricia				1															1				**2**
Kampylaster			1		1		1												1				**4**
Labidiaster					1		1							1	1		1	1	1	1	1		**9**
Lethasterias				1	1	1													1				**4**
Lophaster			1													1	1				1	1	**5**
Lysasterias				1														1	1	1		1	**5**
Luidiaster																				1			**1**
Macroptychaster			1																				**1**
Neosmilaster				1																			**1**
Notasterias					1	1										1	1		1		1		**6**
Notioceramus																1							**1**
Odontaster	1			1	1		1		1	1	1	1	1					1	1				**11**
Patiria																1							**1**
Perknaster					1		1										1		1		1		**5**
Porania			1		1							1				1							**4**
Psilaster			1				1			1	1		1			1			1	1			**8**
Remaster				1																			**1**
Rhopiella																	1						**1**
Sclerasterias														1									**1**
Total	**1**	**–**	**6**	**7**	**7**	**3**	**5**	**–**	**1**	**5**	**3**	**2**	**2**	**2**	**1**	**9**	**9**	**4**	**10**	**5**	**6**	**3**	**91**

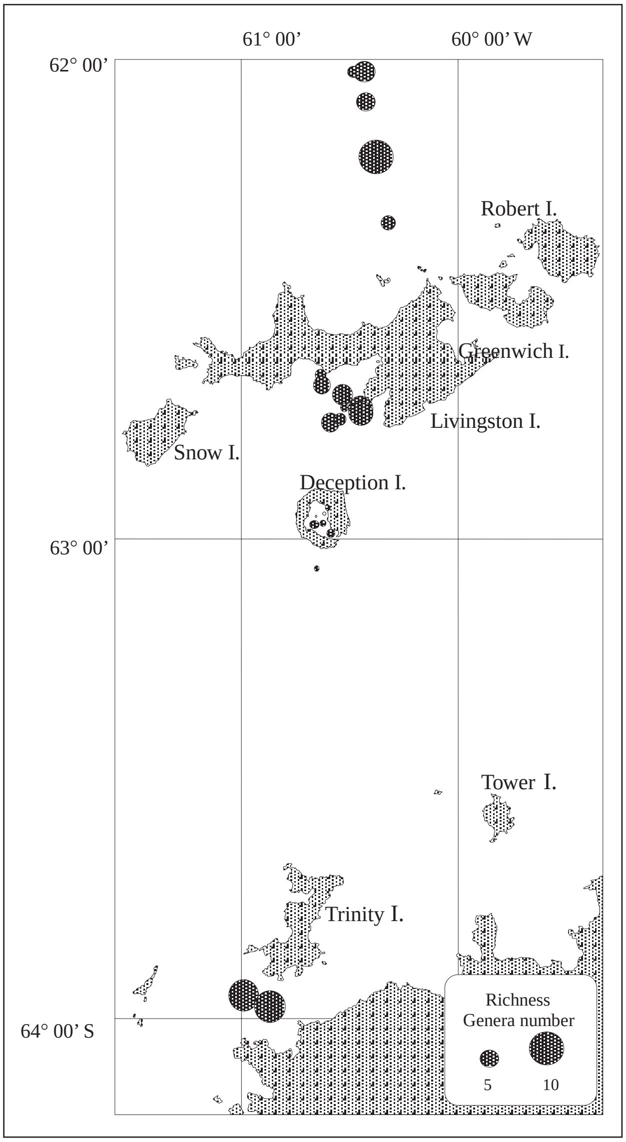

Figure 2. Genera richness by station

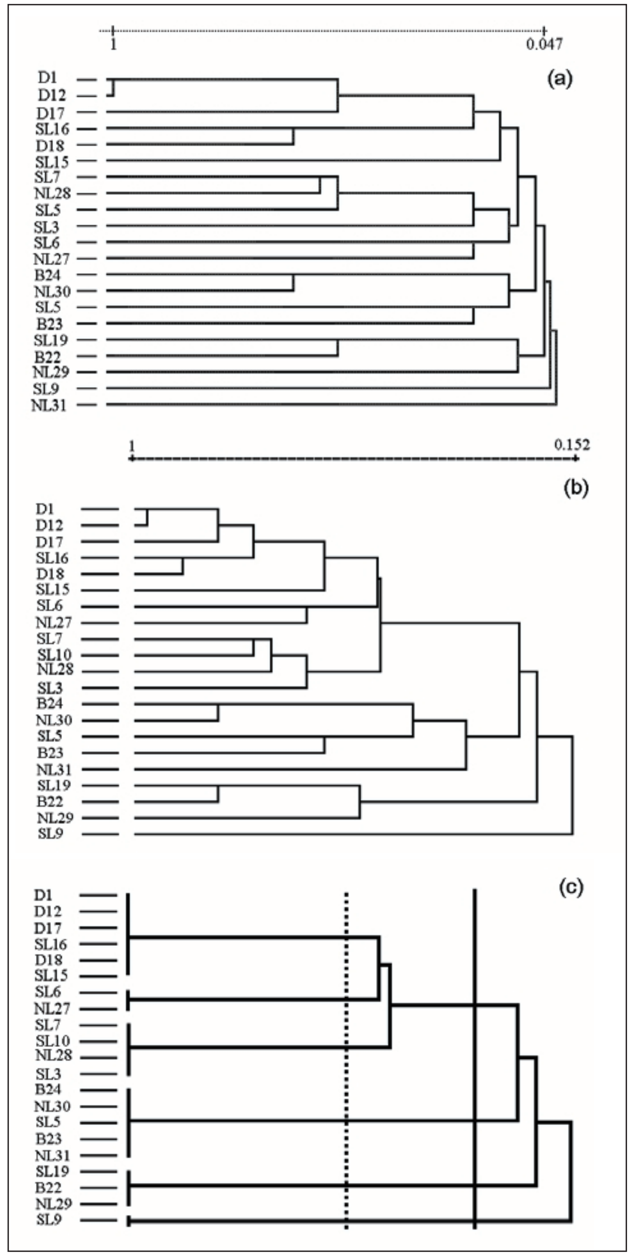

Figure 3. Dendrogram (UPGMA) based on presence-absence of Asteroidea genera: (a): using Jaccard's index; (b): using Baroni-Urbani's index; (c): as a summary after the grouping study

geneity among stations (figure 3a). However, when the Baroni-Urbani similarity index (which takes into account double absences) was applied, we could detect two types of boundaries: one weak, and one strong, which seem to separate the stations inside Deception Bay from the rest (figures 3b and 3).

We found no correlation between the ordering of the stations and environmental variables.

DISCUSSION

Taking into account that 50 asteroid genera have been cited in the entire Antarctic Ocean (Fisher, 1940), that Voss (1988) found 29 of them in the Weddell Sea, and that in our study area Bernasconi (1970) has cited 19, the 27 genera found in this study, taken at only 23 stations in a very reduced area, indicate a very high asteroid richness in the benthic fauna of the South Shetlands and Antarctic Peninsula.

The frequency of *Odontaster*, *Labidiaster*, *Psilaster* and *Diplasterias*, the rarity of genera such as *Notioceramus* and *Chitonaster* (the latter endemic to Antarctic waters), and the abundance of *Odontaster* and *Labidiaster,* all concur with data provided by previous expeditions (Fisher, 1940; Dell, 1972). For example, 87 % of the asteroids gathered in Adelie Land (Arnaud, 1964) and more than 50 % of the specimens collected during the BANZARE Expedition were *Odontaster validus* (Clark, 1962).

Analyses carried out so far, based on genera richness data from the Bentart 95 Survey, show that asteroids are present at 90 % of stations (Arnaud *et al.*, 1998). The most evident result was the difference between the stations at Deception Island and those located elsewhere, an already well-known consequence of this island's volcanic activity (Gallardo *et al.*, 1977; Retamal, 1981; Gallardo, 1987, 1992).

Asteroids have a wide-ranging trophic spectrum (McClintock, 1994), including suspension feeding and necrophagy, such as in *Odontaster* and some other starfishes (Arnaud, 1977; Pressler, 1986) and exclusive predation on hexactinellids, such as in *Acodontaster* (Dearborn, 1977). All of these behaviours, and the high bathymetric tolerance which frequently characterises the Antarctic benthos (Arnaud 1992), are responsible for their wide distribution.

Starfishes can find an ecological niche in any kind of community, even though, as shown by multivariant analysis, the highest richness and total abundance of the group was found in Bransfield Strait and Drake Passage and Miers Bluff Point, coinciding with zones featuring hard bottoms and strong bottom currents. At these stations, communities were dominated by suspension-feeders, above all sponges and bryozoans (Arnaud *et al.*, 1998). Data obtained by Voss (1988) from the Weddell Sea agree with ours.

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